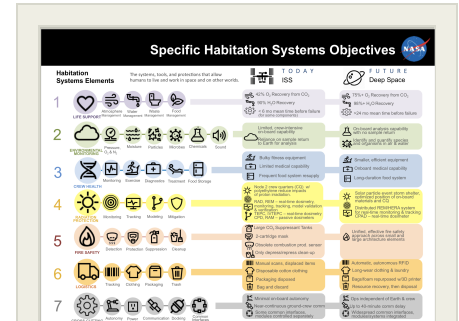## Project Introduction

We propose a machine-learning technology that significantly expands NASA's real-time and offline ISHM capabilities for future deep-space exploration efforts. Our proposed system, Anomaly Detection via Topological fEAture Map (AD-TEAM), will leverage a Self-Organizing Map (SOM)-based architecture to produce high-resolution clusters of nominal system behavior. What distinguishes AD-TEAM from more common clustering techniques (e.g., k-means) in the ISHM-space is that it maps high-dimensional input vectors to a 2D grid while preserving the topology of the original dataset. The result is a 'semantic map' that serves as a powerful visualization tool for uncovering latent relationships between features of the incoming points. Thus, beyond detecting known and unknown anomalies, AD-TEAM will also enable space crew to semantically characterize the clusters discovered. In doing so, personnel will better understand how faults propagate throughout a system, the transitional states of subsystem degradation over time, and the dominant features (and their relationships) of subsystem behavior. In addition to analyzing single subsystem datasets, we also propose to cross-correlate subsystems in order to capture the cascading effect of faults from one subsystem to another, as well as discover latent relationships between subsystems. Such analysis would significantly aid in the maintenance and overhauling activities of NASA's deep-space missions.

Anticipated Benefits

One transition target is **Orbital ATK**, which has expressed interest in AD-TEAM as a potential integration into their ISHM systems. **Orbital ATK has been chosen for innovation under NASA's Next Space Technologies for Exploration Partnerships (NextSTEP-2) program,** so a partnership presents opportunity for integration into **a real NASA space technology.** Another target is the **Sustainability Base at ARC** for us to test AD-TEAM on their datasets, and for them to adapt our research to their ISHM tools.

We have begun conversations with Derek R. DeVries, an Orbital ATK Sr. Fellow Discipline Owner for Propulsion System's Avionics and Control Disciplines. In an official letter of endorsement (attached to this proposal), he believes AD-TEAM has good potential for the PHM systems of **Orbital ATK's Avionics and Control Division.** We plan to grow this relationship with Orbital ATK's Avionics and Control Division through Phase I and Phase II.

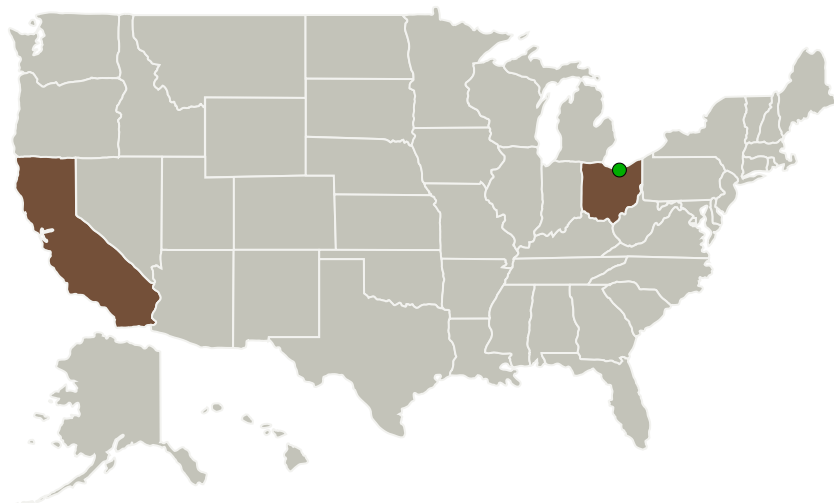Anomaly Detection via Topological Feature Map, Phase I

Table of Contents

Primary U.S. Work Locations and Key Partners

Organizations Performing Work	Role	Type	Location
Stottler Henke Associates, Inc.	Lead Organization	Industry	San Mateo, California
●Glenn Research Center(GRC)	Supporting Organization	NASA Center	Cleveland, Ohio

Primary U.S. Work Locations	
California	Ohio

Project Transitions

▶ **July 2018:** Project Start

✔ **February 2019:** Closed out

Closeout Documentation:
- Final Summary Chart(*https://techport.nasa.gov/file/140931*)

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

Stottler Henke Associates, Inc.

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

Carlos Torrez

Principal Investigator:
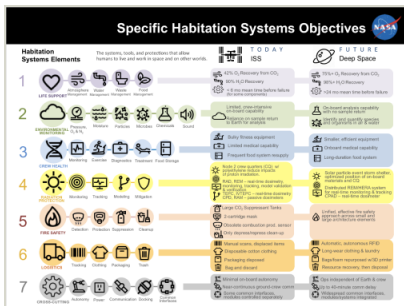
Sowmya Ramachandran

Co-Investigator:

Sowmya Ramachandran

Images

Briefing Chart Image
Anomaly Detection via Topological Feature Map, Phase I
(https://techport.nasa.gov/image/129726)
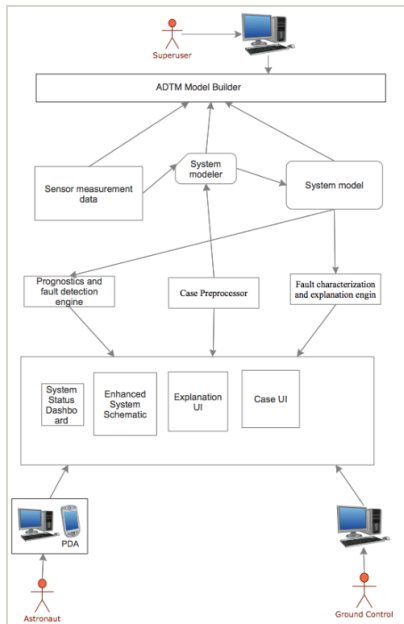
Final Summary Chart Image
Anomaly Detection via Topological Feature Map, Phase I
(https://techport.nasa.gov/image/134245)

Technology Maturity (TRL)

Start: **1**
Current: **4**
Estimated End: **4**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		
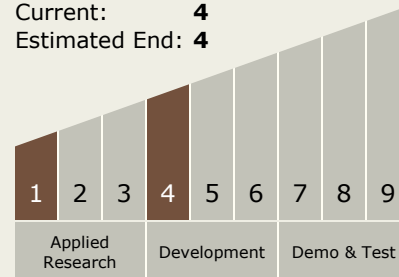
Technology Areas

Primary:

- TX06 Human Health, Life Support, and Habitation Systems
  └ TX06.4 Environmental Monitoring, Safety, and Emergency Response
    └ TX06.4.2 Fire: Detection, Suppression, and Recovery

Target Destinations

Mars, Others Inside the Solar System